NACA

RESEARCH MEMORANDUM

LARGE-SCALE FLIGHT MEASUREMENTS OF ZERO-LIFT DRAG AT

MACH NUMBERS FROM 0.86 TO 1.5 OF A WING-BODY

COMBINATION HAVING A 60° TRIANGULAR WING

WITH NACA 65A003 SECTIONS

By Robert L. Nelson

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

June 1, 1950

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

LARGE-SCALE FLIGHT MEASUREMENTS OF ZERO-LIFT DRAG AT

MACH NUMBERS FROM 0.86 TO 1.5 OF A WING-BODY

COMBINATION HAVING A 60° TRIANGULAR WING

WITH NACA 65A003 SECTIONS

By Robert L. Nelson

SUMMARY

Flight tests were made at high-subsonic and supersonic speeds and at high Reynolds numbers to determine the zero-lift drag of a fin-stabilized body and a wing-body configuration. The 60° triangular wing had NACA 65A003 airfoil sections. The body was parabolic in profile, had a fineness ratio of 10 and a ratio of body frontal area to wing area of 0.0306.

The test results indicate that the wing-body combination had a low drag at supersonic speeds. The drag coefficient based on wing area was approximately 0.0115 for the wing and body with two fins and 0.0068 for the body plus four fins at supersonic speeds. At subsonic speeds the drag coefficient was 0.0065 for the wing and body with two fins and 0.0026 for the body plus four fins. The wing and body with two fins had a force-break Mach number of 0.995. The force-break Mach number for the body with four fins was 0.975.

INTRODUCTION

As part of an NACA program on transonic research, the Langley Pilotless Aircraft Research Division is performing a series of rocket-powered flight tests at Wallops Island, Va., to investigate the aero-dynamic characteristics of several wing-body configurations. These tests provide continuous data from high-subsonic to supersonic speeds at high Reynolds numbers.

This paper presents zero-lift drag data for a fin-stabilized body
and a wing-body configuration having a 60° triangular wing with
NACA 65A003 airfoil section. The body was of parabolic profile with
maximum diameter at 40 percent of the length and had a fineness ratio
of 10. The body frontal area was 3.06 percent of the total wing area.

The wing-body configuration was designed in an attempt to obtain low
supersonic drag by properly combining a wing and body, each having low
drag, so as to take advantage of favorable interference effects. The low
drag characteristics of thin triangular wings are well known. As reported
in reference 1, parabolic bodies having maximum diameters in the neighbor-
hood of 40 to 60 percent of the length were found to have low drag. Ref-
erence 2 shows that a favorable wing-body interference exists when the
wing is placed behind the body maximum diameter. A triangular wing when
placed on a body will have a large chord at the wing-body juncture and
thus it was necessary to select a parabolic body with maximum diameter
at 40 percent of the length in order to place the wing chord completely
behind the maximum diameter and take advantage of the possible favorable
interference.

The Mach number range was from 0.86 to 1.5. Reynolds number, based
on the wing mean aerodynamic chord of 4.84 feet, varied from 20×10^6
to 50×10^6.

MODEL AND TESTS

The general arrangement of the test configurations is presented in
figure 1. Photographs of the models on the launching platform are shown
as figure 2. The body was identical for both configurations and had a
profile formed by two parabolic arcs each having its vertex at the maxi-
mum diameter which was located at 40 percent of the body length. The
body had a fineness ratio of 10 with body frontal area of 3.06 percent
of the wing area. The body and wing profile coordinates are given in
table I. The 60° triangular wing was modified by rounding off the wing
tips so that the resulting wing area was $99\frac{1}{2}$ percent of the basic tri-

angular area. The wing had NACA 65A003 airfoil sections parallel to the
model center line. Four stabilizing fins were used on the wingless body
and two vertical fins were used on the winged configuration. The plan
form and section of the tail surfaces are given in figure 1.

With the exception of the metal stabilizing fins, the models were
principally of wooden construction.

Each model was propelled by a Deacon rocket motor which delivers approximately a thrust of 6200 pounds for 3.2 seconds.

Velocity data were obtained from Doppler radar. Drag data were acquired from Doppler radar and longitudinal accelerations telemetered from the models. Trajectory and atmospheric data were obtained from an SCR 584 radar set and by radiosonde observations.

Some data on base pressure were obtained during both flights. The contribution of the base to the total drag was indicated to be small, being of the order of 6 percent or less.

The estimated accuracy of the results is as follows:

Mach number . . . . ±0.005
Drag coefficient . . . . ±0.0005

The variation of Reynolds number with Mach number is shown in figure 3. The difference between the two curves may be attributed to different flight altitudes and air temperatures.

RESULTS AND DISCUSSION

Curves of drag coefficient against Mach number are given in figure 4. The data for the wing and body with two fins are given in figure 4(a). The data for the body with four fins are given in figure 4(b). From these data and unpublished data on fin drag the wing-plus-interference drag has been determined and the results are presented in figure 4(c). In determining the wing-plus-interference drag, drag coefficients for two fins of 0.0008 at Mach numbers above 1 and of 0.0005 at Mach numbers below 1 were subtracted from the body plus four-fin data. The resulting data for a body with two fins, in turn, were subtracted from the wing and body with two-fin data.

The test results in figure 4(a) show that the wing and body with two fins had a low supersonic drag coefficient. The supersonic drag coefficient for this configuration, based on total wing area, varied from 0.012 to 0.011. At subsonic speeds the drag coefficient was 0.0065. The force-break Mach number was 0.995. The telemeter test point at a Mach number of 0.995 should not be regarded as a stray point since the continuous telemeter record of the model's longitudinal acceleration showed a decrease in drag between Mach numbers of 0.99 and 0.995. This decrease in drag did not occur for the body having four fins.

The drag coefficient for the body with four fins varied from 0.0072 to 0.0064 at supersonic speeds and was 0.0026 at subsonic speeds. The force break for this model occurred at a Mach number of 0.975.

The wing-plus-interference drag coefficient was only slightly greater at supersonic speeds than at subsonic speeds. As shown in figure 4(c), the drag coefficient was 0.0044 at subsonic speeds and increased at supersonic speeds to a value of 0.0054. This small increase agrees with what would be expected for the wing alone and indicates that the objective of combining a wing and body without unfavorable interference effects was achieved. The dip in the wing-plus-interference drag-coefficient curve near a Mach number of 1.0 is also believed to be a favorable wing-body interference similar to that shown in reference 2.

REFERENCES

1. Hart, Roger G., and Katz, Ellis R: Flight Investigations at High-Subsonic, Transonic, and Supersonic Speeds to Determine Zero-Lift Drag of Fin-Stabilized Bodies of Revolution Having Fineness Ratios of 12.5, 8.91, and 6.04 and Varying Positions of Maximum Diameter. NACA RM L9I30, 1949.

2. Mathews, Charles W., and Thompson, Jim Rogers: Comparison of the Transonic Drag Characteristics of Two Wing-Body Combinations Differing Only in the Location of the 45° Sweptback Wing. NACA RM L7I01, 1947.

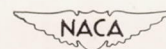TABLE I

BODY AND WING COORDINATES FOR TEST MODELS
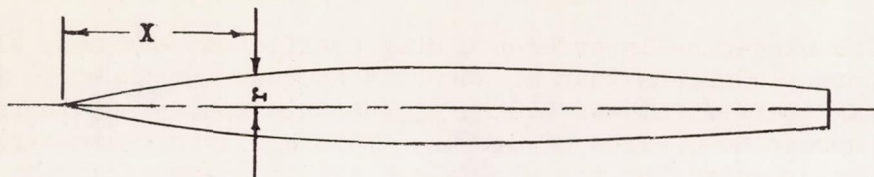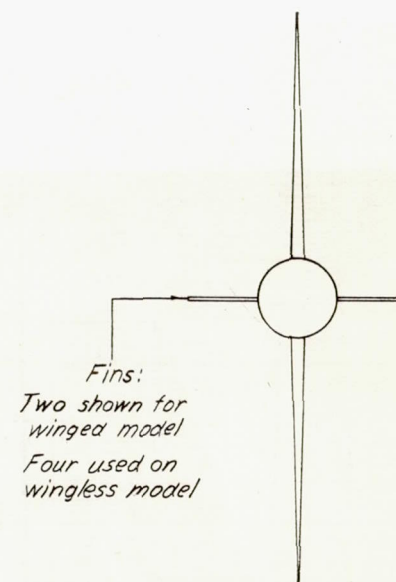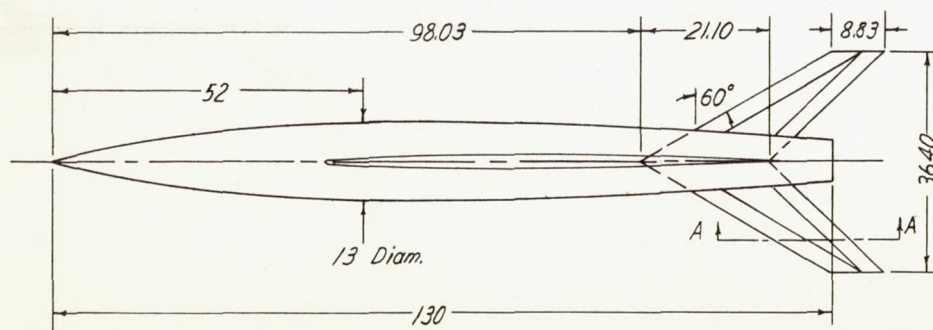

Body Coordinates In Inches

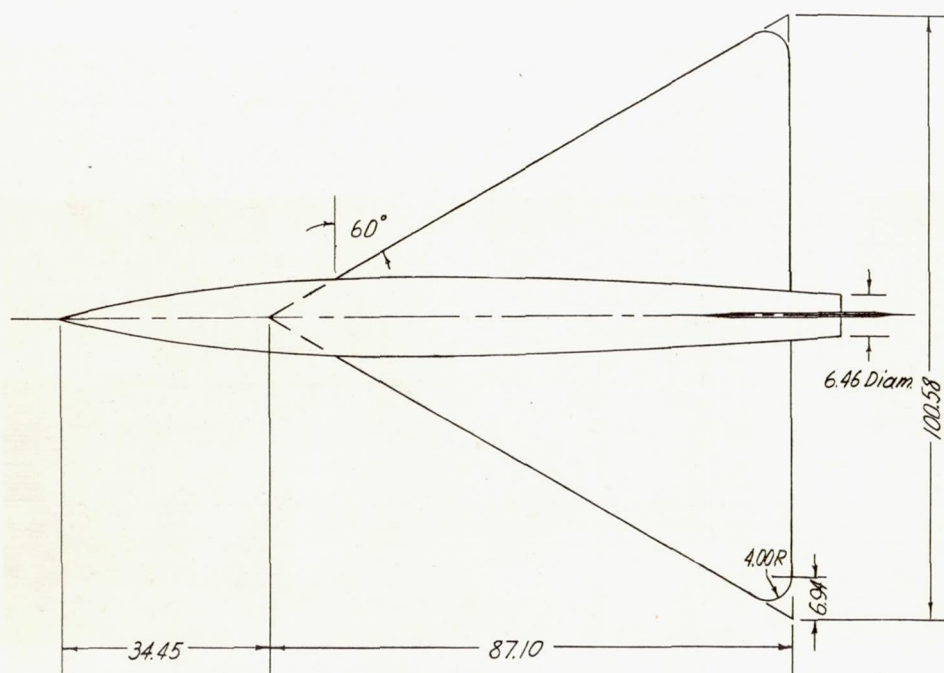| Body coordinates 130-inch parabolic model			
X	r	X	r
0	0	54.60	6.496
0.78	.194	62.40	6.442
1.17	.289	70.20	6.322
1.95	.478	78.00	6.137
3.90	.938	85.80	5.886
7.80	1.804	93.60	5.570
11.70	2.596	101.40	5.188
15.60	3.315	109.20	4.742
23.40	4.534	117.00	4.229
31.20	5.460	124.80	3.652
39.00	6.094	130.00	3.230
46.80	6.435		
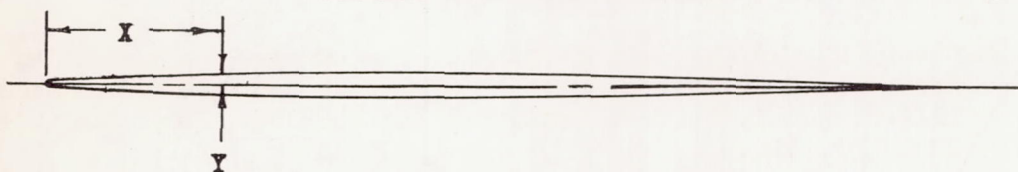
Wing Coordinates In Percent Chord

Wing coordinates NACA 65A003			
X	Y	X	Y
0	0.000	40	1.498
.50	.232	45	1.496
.75	.282	50	1.463
1.25	.359	55	1.397
2.50	.491	60	1.303
5.00	.657	65	1.182
7.50	.796	70	1.044
10.00	.912	75	.888
15.00	1.097	80	.719
20.00	1.237	85	.545
25.00	1.344	90	.364
30.00	1.421	95	.185
35.00	1.473	100	.007
L.E. radius = 0.115c			
T.E. radius = 0.007c			

60°

6.46 Diam.

100.58

4.00 R

6.94

34.45

87.10

Fins:
Two shown for
winged model

Four used on
wingless model

All dimensions in inches

98.03

21.10

8.83

52

60°

36.40

13 Diam.

A

A

130

.375
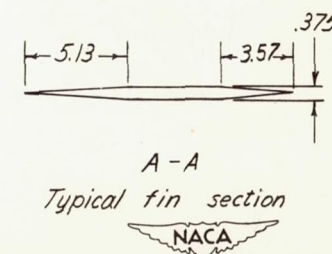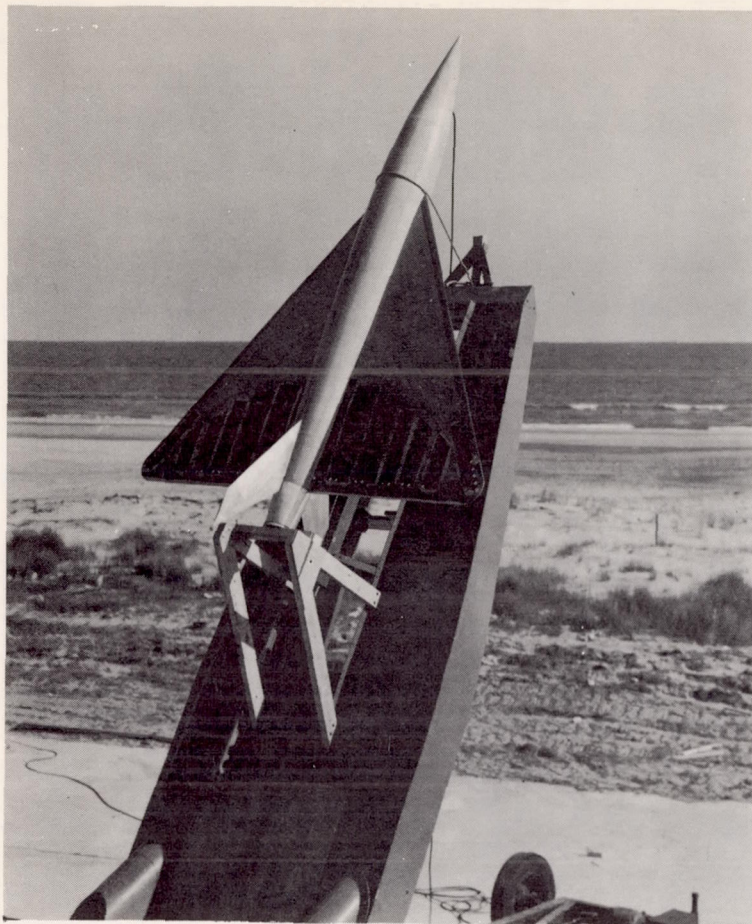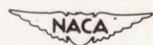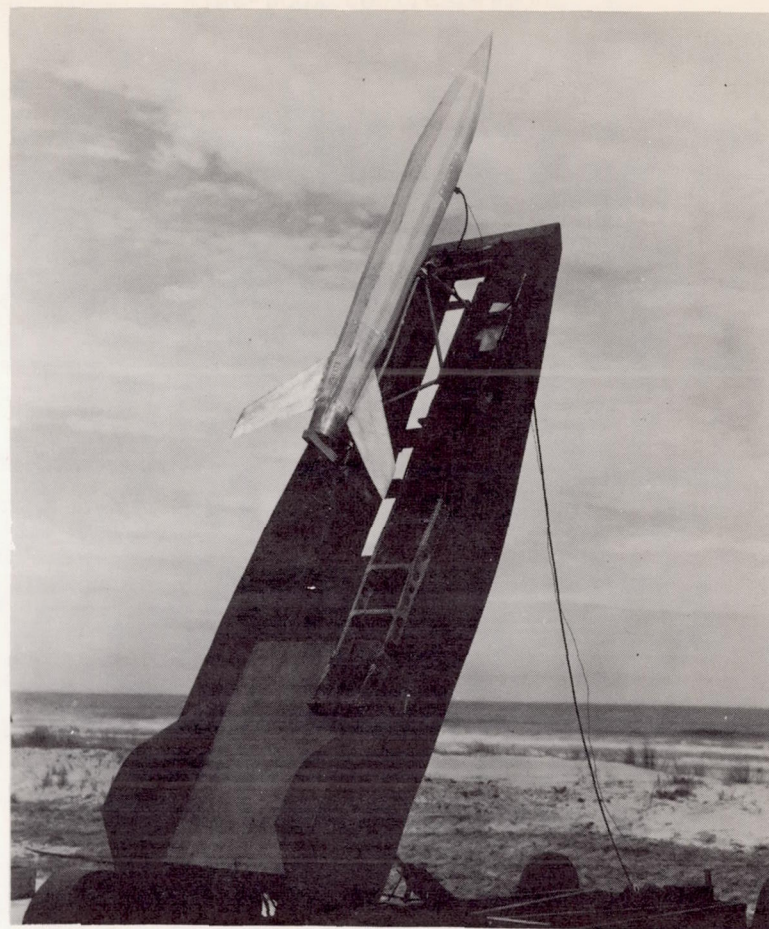
5.13

3.57

A - A
Typical fin section

NACA

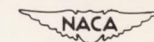Figure 1.- General arrangement of test model. Wing-body configuration
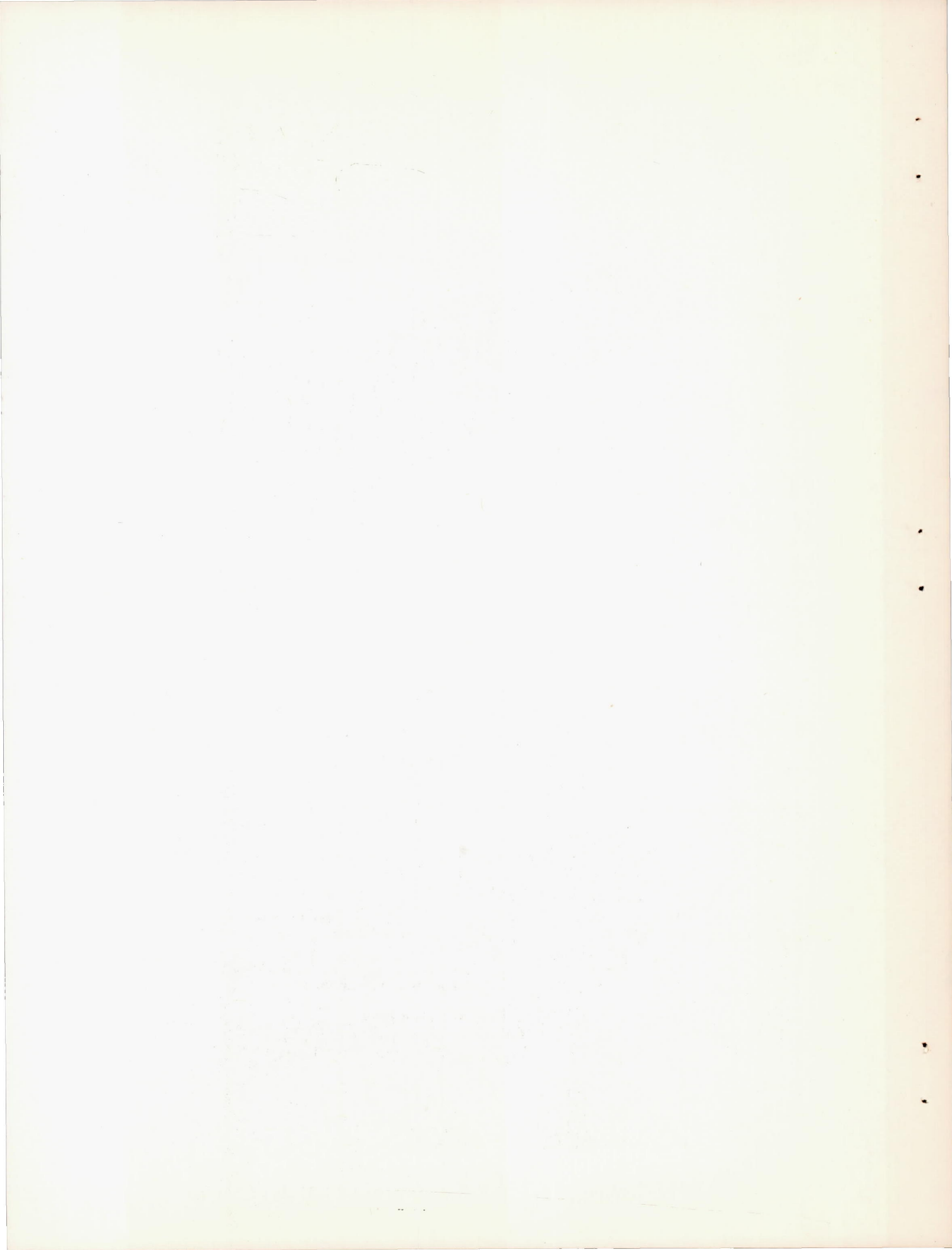shown.

(a) Wing-body.

L-64583

(b) Body.

L-62945

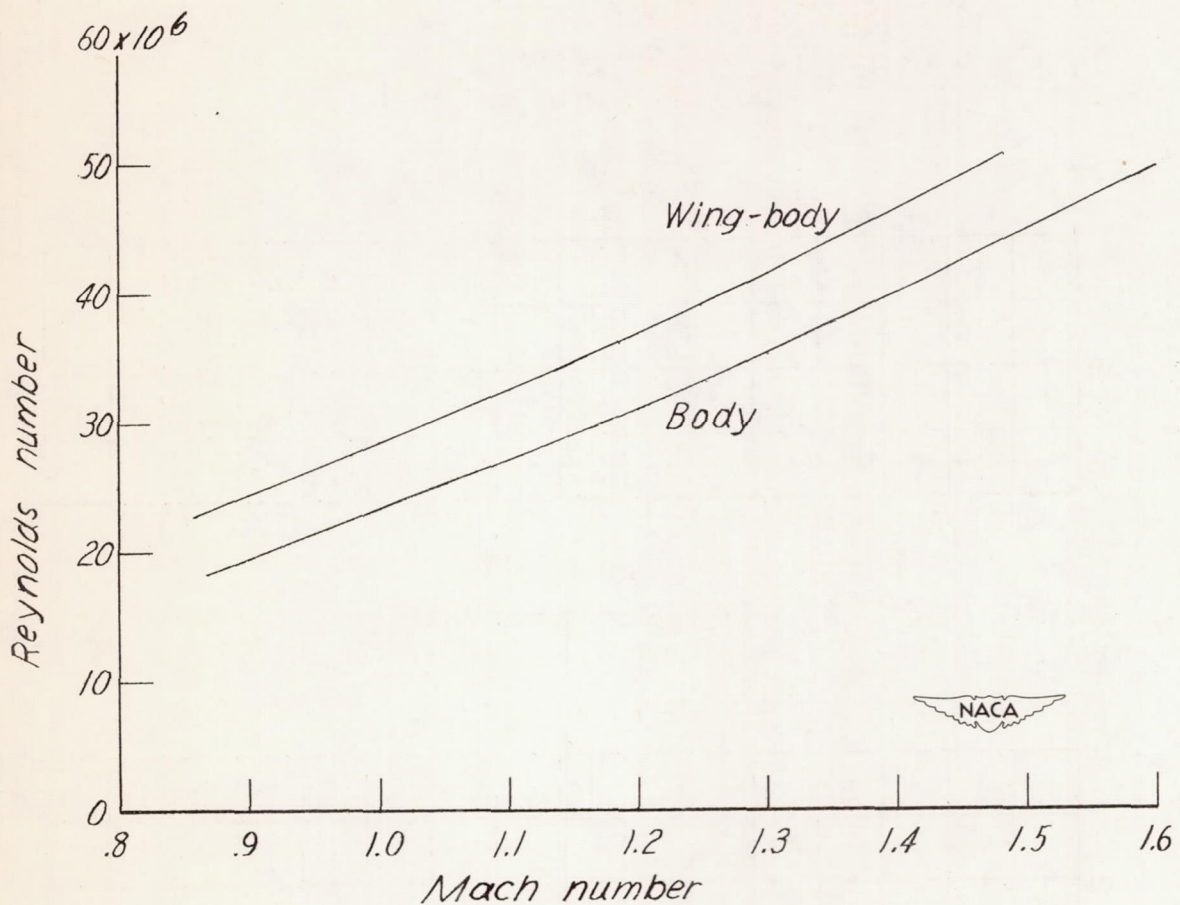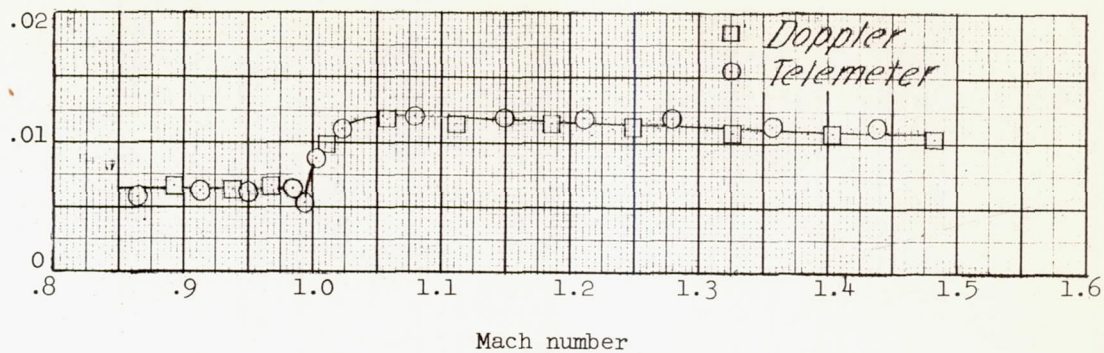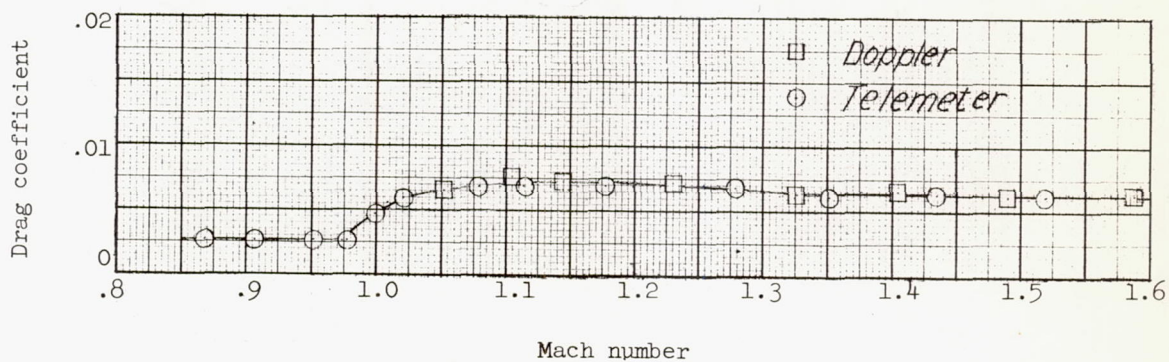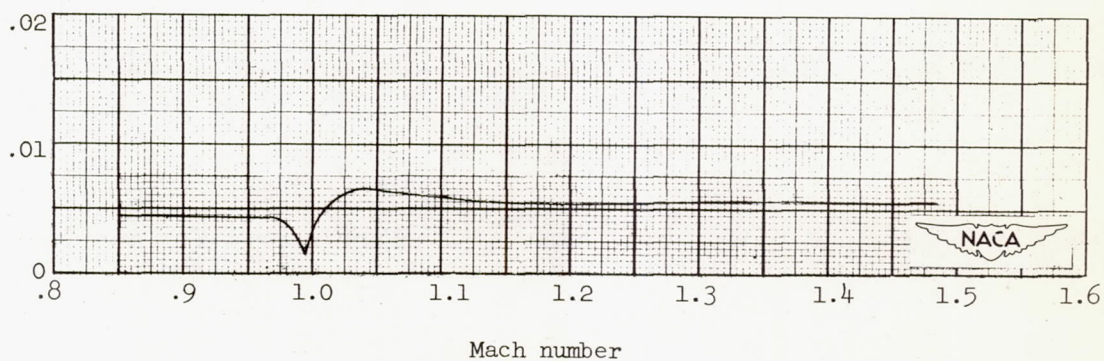Figure 2.- Models in launching position.

Figure 3.- Variation of Reynolds number with Mach number for test models. Reynolds numbers are based on wing mean aerodynamic chord of 4.84 feet.

(a) Wing-body (two tail fins).

(b) Body (four tail fins).

(c) Wing plus interference.

Figure 4.- Variation of drag coefficient with Mach number based on total wing area of 30.27 square feet.